DEVELOPMENT OF SPATIAL IMAGINATION WITH THE HELP OF DRONES

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Abstract: This article deals with the improvement of spatial visualization using drones. Spatial imagination is one of the essential abilities for life. A person lacking this ability would not be able to orientate in space and would not be able, for example, to estimate the size of a room or how far an object is placed. The aim of the research was to improve spatial visualization with the help of drones. Drones represented an element defining certain distances, and the change in distance estimation using drones in free flight, drone programming, and displaying of distance without drone were analysed.

Keywords: spatial imagination, drone, distance estimation, estimation, distance, development, education.

1 Introduction

The development of spatial imagination is needed to ensure orientation in space, to find out how far away an object is placed, or how big various objects are. The article focuses on the distance estimation. There has been a great development of drones even as a hobby nowadays. The connection of spatial imagination and drones for the improvement of spatial imagination is described in the article.

2 Spatial Imagination

The concept of spatial imagination includes many things. Everyone will probably imagine the ability to orientate in space, for example, to estimate the size of a room, the amount of space between a person and a target, or how far away an object is placed. Spatial imagination is very useful and essential for everyday life. Pilots, designers, artists, but also mathematicians and physicists would surely not manage without spatial imagination. Before defining the concept of spatial imagination, terms related to it have to be described.

2.1 Imagination

The term imagination means, for example, the ability [1].

Imagination is also understood as the ability to recollect and create ideas. Thus, the idea is an image created in mind and based on perception, intellectual activity or experience [2].

Another definition classifies imagination into cognitive processes associated with memory. Imagination is defined as the ability of our consciousness to create ideas, i.e. sensory images of something we do not perceive at the moment, or to recall past experiences [3].

Connection between the past and the present is thus one function of the imagination [3].

Imagination is also described as an active and constructive process of creating new thought images on the basis of perception and experience, as a mental operation with ideas. Idea is thus defined as a memory reproduction of perception, or a perception transformed by imagination or visualization [4].

Another definition of imagination is a mental construction that man creates in connection with past events (e.g. the image of natural scenery from last year´s holiday), future phenomena (e.g. the idea of an engineer about a designed bridge), and phenomena that are not immediately perceived by his/her senses [5].

The image can also be defined as a subjective part of the mental depiction of reality, both of the objectively existing reality and the phenomena that have not existed so far, but are originally created through ideas [2].

It can also be said that the concept of imagination in art is the creation of images and thoughts without the presence of a sensory stimulus. It forms sections of previous sensory experience into new units. [6].

Imagination is also a psychological reconstruction of an event or object [7].

Another definition understands imagination as a transient effect between sensory and abstract experience of reality. It includes creating new images, ideas, notions and their combinations. Imagination is a reflection of a social environment in which one gains knowledge and experience. Imagination of a person with a low level of knowledge and experience will differ from imagination of a person living in an environment rich in various stimuli [8].

Imagination is also the ability to imagine things that are not present and to combine images [9].

It is also a process of recollecting already experienced events and their application to new contexts [10].

Imagination can also be explained as the ability or skill to recollect previously seen objects, including their properties, place and spatial location; objects seen at a given moment even in a different position than they were initially perceived; objects in three-dimensional space seen in two-dimensional space; non-existing objects only on the basis of their verbal description [11].

Another definition states that images are not caused only by immediate perceptions, but also by perceptions that are not being perceived at the moment. That is why imagination is associated with memory, and when creating ideas, a person uses images and facts stored in memory [12].

A number of definitions proves that the concept of imagination is very extensive, and that imagination and memory are being used, a comparison of what was seen before.

2.2 Space

Space is defined by means of three coordinates. Horizontal, vertical and front-rear axis. Thanks to these three axes, space is perceived as three-dimensional. The horizontal axis is used to see from left to right. The vertical axis is used to see up and down and the front-rear axis is used to determine what is in front and back.

2.2.1 Spatial Perception

Depth perception is necessary for orientation in space. The vision uses several various techniques to perceive space.

Visual Techniques:

a) “Focusing – to see objects placed in different distance clearly.
b) Convergence of optical axes – it is important when we perceive something using both eyes, the object is first projected on each eye separately, and then the perception is combined into one image to achieve binocular vision.
c) Size of an object – we are able to estimate it using our experience, however it is relative and depends on the size of retinal image.
d) Overlapping – we are able to estimate depth and distance of an object thanks to the objects that overlap in different distances.
e) Shading – helps us to understand another view of the object, because shadows on uneven surfaces of objects create a kind of relief.
f) Different placement of objects in the field of sight – it is important where the object is located, whether objects

placed side by side are of the same size or if one is smaller – then we can assume that the smaller object is at a greater distance. It is about understanding figure and background.

g) Perspective – our eye perceives two kinds of perspective, linear and aerial. The linear perspective is a convergence of vanishing points to one point and a continuous reduction of objects. The aerial perspective works with colour changes, closer objects are displayed in richer and darker colours than distant objects. With the distance of the object, the colour gradually fades and disappears." [13].

In term of the development of space perception, this ability is developed in the first year of child´s life. The development is influenced by visual and auditory perception, locomotion and object handling. Space in the vertical plane, i.e. what is up and what is down, begins to be perceived as the first one. Subsequently, space is perceived in front-rear plane, i.e. what is in front and what is in back. Space in the horizontal plane, i.e. what is on the right and on the left, is perceived as the last one. The right-left orientation is the most difficult. [14]

2.3 Spatial Imagination

The basic concepts of spatial imagination were defined in the above mentioned points. It is now possible to deal with a specific definition of spatial imagination. There are many definitions and some of them will be given here.

By spatial imagination we understand the intellectual ability (skill) to recollect:

a) Previously seen – perceived objects in three-dimensional space and to recall their properties, location and spatial aspects
b) Seen previously or at a given moment – perceived objects are in a position that differs from what it was or how they are actually perceived
c) Object in space based on planar image

d) Non-existent real object in three-dimensional space based on its verbal description [11].

Another definition states that spatial imagination is a set of abilities that relate to images of shape and interrelationships between geometric configurations in space [5].

Another definition says that spatial imagination is a set of partial abilities related to our ideas of space, of shapes and interrelationships between bodies, between the objects and us, and of spatial aspects between parts of our body [16].

Spatial imagination can also be understood as a set of abilities that are influenced by the properties of mental processes. For example, by perception, by intellectual activity with ideas, by recalling, generalization, use of memory etc. Good spatial imagination is very important for technical or designing field of thinking. People with a well-developed spatial imagination can quickly orientate in an unfamiliar environment, they e.g. interpret maps, plans and drawings correctly [17].

Spatial imagination can be also understood as spatial intelligence. Its core is formed by abilities that ensure accurate perception of visual world, that allow transforming and modifying original perceptions, and create ideas based on their own experience, even if there are no external stimuli [18].

Space imagination can also be a set of three important skills that complement each other. Those are the following abilities:

a) Spatial orientation – location of man in the environment
b) Visualization – ability to imagine the interrelationship of objects that are placed into certain positions
c) Kinaesthetic imagination – ability to determine the resulting movement of different gears. [7].

Spatial imagination is also based on learning about the shapes of different objects, their placement and movement in some space. As technology and computers evolve, it is more and more important to develop spatial imagination. [11]

Spatial imagination is therefore a very extensive concept that is not always precisely defined. However, it is a significant topic and it develops many essential abilities. [19 - 22]

3 Drones

Drones, or unmanned aerial vehicles, are systems that have been booming recently. Quadcopter or multicopter drones remotely controlled are most popular nowadays. They are used for both entertainment and commercial applications. Most models are sold for taking pictures or videos. [23] Figure 1.

Figure 1 – Drone [24]

Drones became very popular especially for the recreational use, i.e. taking pictures, shooting videos or just simple flying. In addition, various types of drone races have developed all over the world recently. The FPV Racing is the best known. A large number of smaller drones with high-resolution sensors is therefore produced. There is also great progress in the area of aviation safety. Drones also have different aerial modes. Drones are equipped with sensors that allow the drones to avoid obstacles, to follow the moving target object, and all that autonomously. [25]

Drones are no longer a privilege of several dedicated experts or enthusiastic amateurs, but also people with no experience with drones can get them. That is why, in better cases, drones often end up on trees, and in worse cases, on roofs of buildings or in power lines. It may even happen, and it happens that the drones injure passers-by or even the drone pilot. [26]

The precise definition of a drone is as follows: "Unmanned aerial vehicles, also known as drones, are aerial vehicles that do not carry a human operator, that are operated remotely or can fly autonomously according to predefined flight plans or more complex dynamic autonomous systems." [27]

The term "drone" is not entirely correct for commercial purposes. Experts do not use this term, it is rather a slang term for abbreviated naming of these machines or for communication with the general public. This term can be most commonly found in the media, online discussions, hobby shops or e-shops. The correct name for drones is unmanned aerial vehicles (or whole systems). This designation is mainly used on continents outside Europe (North and South America, Australia, Africa, Asia). A better and more accurate term is used in Europe, the term Remotely Piloted Aircraft Systems. [25]

4 Using Drones in Education

There are several organizations around the world that use drones in education. For example, the Drobots Company organizes STEM Summer Programs For Kids & Teens, which includes Drone Summer Camps For Kids & Teens. [28]. The Company says: "Drobots Company was originally founded by a small group of parents, educators, visionaries and do-it-yourself engineers. The mission was and still is to inspire students to reduce time in front of a computer screen and instead utilize drone technology in a setting that promotes collaborative project-based learning in a positive educational environment. Hence, the company trademark slogan, Where Technology Meets Fresh Air™.

The primary goal of any Drobots Company program is to mentor participants on how to become lifelong learners and instill a strong sense of curiosity, confidence and teamwork. Due to the exponential growth of the drone industry, kids and teens may now explore, learn and evolve along with the applications of today and the discoveries of tomorrow. Drobots fosters this new technological landscape with a unique curriculum and well-trained positively motivated instructors

At Drobots we create flexible experiences that shift students between the excitement and hands-on activities of our indoor activities and the freedom and exploration of the outdoors. Participants utilize imagination, hand-eye coordination and STEM applications to conquer challenges and missions – all in a team-oriented environment. Under the umbrella of a friendly competitive and gamified teaching and learning methodology, participants collaborate in a team setting to deconstruct challenges and then solve them.

The core foundation of our company and the programming we work diligently to develop is built upon creativity, exploration, technology and fun. Our commitment and passion is derived from the unlimited positive applications of innovative technology. Throughout all of our kids camps and teen programs students thrive under the supervision of an adult-led staff committed to the development of the individual and team.

Safety is our #1 priority and our rigorous hiring standards attract the best instructors in the country. At Drobots Company we understand that instructors with years of experience working with kids and teens is the key difference between a good experience and a GREAT experience. Our family of instructors embodies the passion and creativity that we strive to inspire in every participant."

Examples of using drones in education are shown in the following pictures. Fig. 2, Fig. 3, and Fig. 4.

Figure 2 – Example of using drones in education [28]

Figure 3 – Example of using drones in education [28]

Figure 4 – Example of using drones in education [28]

4.1 Drone Ryze Tello

Drone Ryze Tello is a mobile programming app that supports Scratch. Students can command Tello to perform corresponding movements by dragging coding blocks on their smart mobile device, students can also develop programming skills by playing games and completing levels. [29] Fig. 5.

Figure 5 – DJI Ryze Tello [29]

DJI Ryze Tello is an affordable drone made by the DJI Company. To develop the drone, the company has cooperated with the Ryze Techs and Intel Companies. However, price is not the only thing that attracts attention. It is a very small model and both children and adults will enjoy it and have a lot of fun. It weighs only 80 grams. The Tello application with a friendly user interface provides a complete control. Two effective antennas SmartSwitch 2 ensure stable and perfect transmission of image and all your instructions.

Despite its miniature size, DJI Tello can stay in the air up to 13 minutes. The Intel Movidius Myriad 2 VPU processor controls all computing as well as great image output. A situation, when the connection between the mobile phone and the drone is lost has also been considered – in such case, the FailSafe technology ensures a safe landing of a quadcopter.

Drone DJI Tello is programmable in Scratch – a coding system developed by the MIT Company. This software allows both children and adults to learn coding and enjoy fun at the same time. If you consider yourself a more advanced user, with the help of the Tello SDK, it is possible to directly develop software apps for the DJI Tello. Fig. 6.

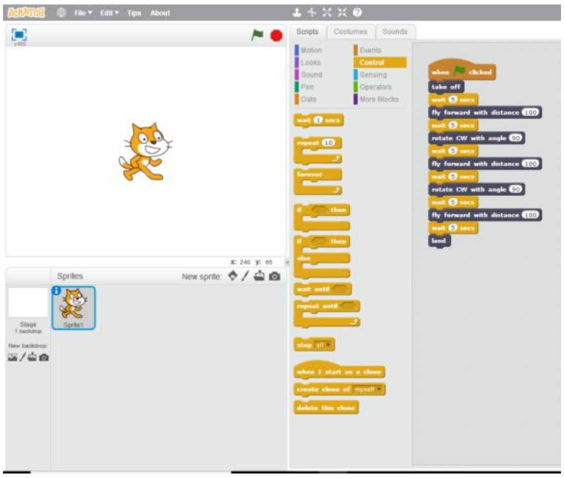

Figure 6 – Coding with Ryze Tello [29]

5 Development of Spatial Imagination with the Help of Drones

The aim of this article is to determine whether drones have an effect on spatial imagination.

5.1 Methodology

A pedagogical experiment was carried out as a method, using a pre-test and a post-test. Groups of students were divided into three groups. The first group participated in the experiment without drone. The second group took part in the experiment with drone which was controlled via joystick application on a smart mobile device, it means it was a free drone flight. The third group also participated in the experiment using a drone, but this time the drone was programmed.

The experiment was focused on distance estimation. Three random distances were marked on the ground and students were to estimate them in centimetres. Their estimates were recorded in the pre-test. Removal of random distances followed and five distances from 1 to 5 metres were drawn. Students of the first group (without drone) remembered those distances. Distances were marked again for the second group of students (free drone flight), but the drone was used to emphasize distances. The drone took off, flew 1 metre and landed. This repeated similarly for other distances up to 5 metres. The aim of using the drone was to inculcate distance estimation in students. The third group of students experienced the same experiment as the second group, but the drone was not controlled by joystick, it was programmed. First, a distance of 1 meter was set. The drone took off, flew the given distance and landed. This process was the same for other distances. The goal of this method was to learn how to estimate distances with the help of drone. Installing the idea of distances of 1 to 5 metres was followed by a post-test. The post-test had exactly the same scenario as the pre-test. It means, three random distances were marked on the ground and the students were supposed to estimate the distance.

The pupils were selected on the basis of an expression of interest from a grammar school. All pupils were from one grade (Quarta) - 9th grade elementary school. It was an even distribution of girls and boys.

5.2 Results

To process the results, a relative difference of distance was used. If the differences are compared with the actual values, it is clear from the charts that there is a significant difference in dispersion of values (homogeneity of the set). There are significant differences between data without drone and with drone, as well as drone free flight or programmed drone flight. Figure 7. The Levene test for equality of variances was used. Table 1 a 2.

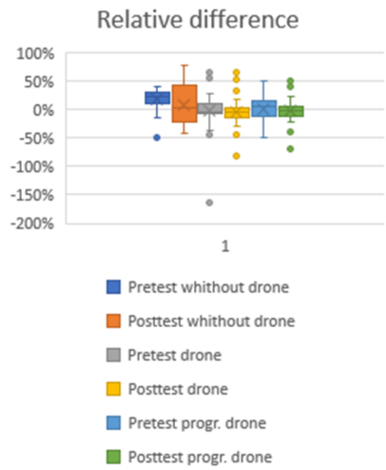

Figure 7 – Relative difference

Tab. 1: Levene Pre-test

	Levene Test for Equality of Variances Mark. effects are significant at the level p < ,05000							
Variable	SS effect	DF effect	AS effect	SS error	DF error	AS error	F	p
Value	0,05 3224	2	0,02 6612	4,56 3445	135	0,03 3803	0,78 7256	0,45 7170

Tab. 2: Levene Post-test

	Levene Test for Equality of Variances Mark. effects are significant at the level. p < ,05000							
Variable	SS effect	DF effect	AS effect	SS error	DF error	AS error	F	p
Value	0,72 3634	2	0,36 1817	3,24 9600	135	0,02 4071	15,03 117	0,00 0001

6 Conclusion

One would not manage without spatial imagination. It is one of the essential skills. Analysing the effect of drones on spatial imagination and the effect of drones on distance estimation reveals significant differences between data obtained without drone and with drone regarding both free and programmed drone flight.

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